Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/CA05/000285

International filing date: 25 February 2005 (25.02.2005)

Document type: Certified copy of priority document

Document details: Country/Office: US
Number: 60/547,768
Filing date: 27 February 2004 (27.02.2004)

Date of receipt at the International Bureau: 27 April 2005 (27.04.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)

PCT/CA 2005000285

PA 1292717

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

March 09, 2005

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE UNDER 35 USC 111.

APPLICATION NUMBER: ***60/547,768***
FILING DATE: ***February 27, 2004***

By Authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS

L. Edelen

L. EDELEN
Certifying Officer

PTO/SB/16 (08-03)
Approved for use through 07/31/2003, OMB 0651-0032
U.S. Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No.

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
1) Peter	1) RADZISZEWSKI	1) Baie d'Urfe, Quebec, CANADA
2) Sudarshan	2) MARTINS	2) Montreal, Quebec, CANADA
3) Coleman	3) BENSON	3) Dollard-des-Ormeaux, Quebec, CANADA

☐ Additional inventors are being named on the ____ separately numbered sheets attached hereto

TITLE OF THE INVENTION (500 characters max)

WEAR SENSOR

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

☐ Customer Number

OR

☒ Firm or Individual Name: GOUDREAU GAGE DUBUC

Address	The Stock Exchange Tower				
Address	800 Place Victoria, Suite 3400				
City	Montreal	State	Quebec	ZIP	H4Z 1E9
Country	CANADA	Telephone	514.397.5170	Fax	514.397.4382

ENCLOSED APPLICATION PARTS (check all that apply)

☒ Specification Number of Pages: 9
☒ Drawing(s) Number of Sheets: 8
☐ Application Data Sheet. See 37 CFR 1.76
☐ CD(s), Number
☐ Other (specify)

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☐ Applicant claims small entity status. See 37 CFR 1.27
☐ A check or money order is enclosed to cover the filing fees
☒ The Director is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 07-1742
☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT ($): $160.00

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No
☐ Yes, the name of the U.S. Government agency and the Government contract number are: ____________

Respectfully submitted,

SIGNATURE ____________ Date: Feb. 27, 2004

TYPED or PRINTED NAME: Hugh MANSFIELD

REGISTRATION NO. (if appropriate): 55757

TELEPHONE: 514.397.5170

Docket Number: 11168.225

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

This collection of information is required by 37 CFR 1.51. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the completed application to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop Provisional Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2

TITLE OF THE INVENTION

[001] WEAR SENSOR

BRIEF DESCRIPTION OF THE DRAWINGS

[002] Figures 1a and 1b disclose a wear sensor in accordance with an illustrative embodiment of the present invention;

[003] Figure 2 discloses a wear sensor in accordance with a first alternative illustrative embodiment of the present invention;

[004] Figure 3 discloses a wear sensor in accordance with a second alternative illustrative embodiment of the present invention;

[005] Figures 4a and 4b disclose a printed wear sensor in a accordance with an illustrative embodiment of the present invention;

[006] Figure 5 discloses a ball mill;

[007] Figures 6a through 6d disclose various lifter profiles for use in a mill; and

[008] Figures 7a and 7b disclose the application of the wear sensor in a lifter for use in a mill in accordance with an illustrative embodiment of the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

[009] Referring to Figure 1a, an illustrative embodiment of a wear sensor in

accordance with an illustrative embodiment of the present invention. The wear sensor, generally referred to using the reference numeral 10, is comprised of a component 12 in which wear is to be sensed. The component has at least one wear surface 14 which will be slowly eroded through, for example, contact with abrasive articles or the like (not shown). An opening 16 is machined or otherwise moulded into the component 12 with the tip 18 of the opening 16 being positioned in proximity to the wear surface 14. An element 20 is inserted into the opening 16 and secured therein using a matrix 22. The matrix 22, for example, is a non-conductive self hardening compound such as epoxy resin or the like.

[010] In an alternative embodiment, the element 20 could be directly moulded into the component 12 during fabrication, or comprise a lamination within the component 12.

[011] Still referring to Figure 1a, the element 20 is comprised of a first conductor, or signal relaying path, 24 and a second conductor, or signal relaying path, 26 interconnected by a conductive, or signal relaying, bridge 28 toward the ends of the first conductor 24 and the second conductor 26. The element 20 is fabricated, for example, from a 24 gauge copper wire which is simply bent over on itself prior to insertion into the opening 16. Use of a small gauge wire or the like as element allows the size of the opening 16 to be reduced, thereby lessening the impact machining of the opening 16 may have on the structural integrity of the component in which the wear is being tested.

[012] In order to aid in maintaining the first conductor 24 and the second conductor 26 electrically isolated from one another along their lengths, a wire having an insulating jacket could also be used. The ends of the first conductor 24 and the second conductor 26 of the element 20, which project beyond the matrix 22, provide a pair of contacts 30, 32.

[013] In operation, the state of the signalling paths is determined by sensing whether a signal transmitted via one contact 30 is received by a receiver attached to the other contact 32. Illustratively, this is determined by measuring the resistance between the contacts 30, 32 (for example, by applying a voltage V, or alternatively a current, to one of the contacts 30, 32 and measuring the voltage across a resistor 34 placed between the other contact and ground 36). If the resistance is suddenly increased, then this is an indication that the first conductor 24 and the second conductor 26 have been isolated from one another (i.e. the element 20 has been damaged).

[014] Referring now to Figure 1b in addition to Figure 1a, as the wear surface 14 is eroded, the tip 18 of the opening 16 will eventually be exposed. Further erosion of the wear surface 14 will cause the matrix 22 also to be eroded. When the erosion of the wear surface 14 has progressed to the level of the element 20, the first conductor 24 will become isolated from the second conductor 26 due to the removal of the conductive bridge 28. As will now be apparent to a person of ordinary skill in the art, isolation of the first conductor 24 from the second conductor 26 will cause the voltage across the resistor 34 to drop to the ground 36, thereby providing and indication that the erosion of the wear surface 14 has reached depth D in the region of the element 20.

[015] In an alternative embodiment, the first signal relaying path 24, the second signal relaying path 26 and the signal relaying bridge 28 could be fabricated from an optic fibre. In this regard, instead of a voltage/resistance network or the like placed across the ends of the first signal relaying path 24 and the second signal relaying path 26 for sensing isolation of the paths 24, 26 from one another, a light emitting and sensing network would be used.

[016] Referring now to Figure 2, a wear sensor 10 in accordance with an

alternative embodiment of the present invention will now be described. In environments where the wear surface 14 is in contact with erosive materials which are also capable of conducting electricity, for example erosive slurries comprised of one or more ionic salts suspended in an aqueous medium, erosive removal of the conductive bridge 28 may not result in the isolation of the first conductor 24 from the second conductor 26. In order to overcome this limitation, a second isolated conductive element 38 is inserted into the opening 16 together with the original conductive element 20 such that tip 40 of the second conductive element 38 is located in proximity to the tip 18 of the opening 16. The original conductive element 20 and the second conductive element 38 are then secured therein using the matrix 22 leaving the ends of the original conductive element 20 exposed thus providing a pair of contacts 30, 32 and leaving the end of the second conductive element 38 exposed, thus providing a third contact 42.

[017] Still referring to Figure 2, as the wear surface 14 is eroded to depth D the conductive bridge 28 will be removed and the ends of the first conductor 24, the second conductor 26 and the second conductive element 38 exposed. By coupling a sufficiently large resistor 34 between the contact 32 and ground 36 and coupling the third contact 42 to ground 36 (thus effectively grounding the second conductive element) the majority of the current flowing along the first conductor 24 (a the amount of current which follows a given path is inversely proportional to the resistance of that path) will flow via the second conductive element 38 to ground 36. Once again, by measuring the voltage across the resistor 34, a drop in voltage will indicate that the erosion of the wear surface 14 has reached depth D in the region of the conductive element 20 and damaged the conductive element 20. Additionally, in order to protect against short circuit of the voltage source V, provision of a second resistor 44 between the voltage source V and the contact 30 may also be provided for.

[018] Referring now to Figure 3, a wear sensor 10 in accordance with a second alternative illustrative embodiment will now be described. In applications where it is wished to determine the amount of wear on a wear surface 14 of a component 12, provision of a single conductive element 20 comprised of a first conductor and a second conductor may prove insufficient. In order to overcome this limitation, a conductive element 20 comprised of a first conductor 24 and a series of second conductors as in 46 is provided for. The second conductors as in 46 are arranged vis-à-vis the wear surface 14 such that erosion of the wear surface 14 will cause the second conductors as in 46 to be successively isolated from the first conductor 24. As will now be appreciated by one of ordinary skill in the art, by measuring the resistance between the end 30 of the first conductor 24 and the ends as in 48 of the second conductors as in 46, for example by supplying voltage V (or current) to the first conductor and measuring the voltage across a series of resistors as in 50 placed between the ends as in 48 of the second conductors as in 46 and ground 36, the erosion of the wear surface 14 can be determined at a number of different depths D_1, D_2, D_3, etc..

[019] Referring now to Figure 4a in addition to Figure 3, in order to simplify and provide more accurate placement of the conductive element 20 within the opening 16 in the component 12, the element 20 can be patterned using, for example, a copper film on a suitable substrate 52, such as polyester or polyamide and the like, resulting in a flexible printed circuit. The substrate 52 can then be fastened to a non-wear internal or external surface (for example, perpendicular to the wear surface 14) using a suitable bonding technique such as an epoxy resin adhesive or the like, or laminated into the component 12 during fabrication. Referring to Figure 4b, alternatively, the printed medium could be rolled up to form a tube and inserted into the opening 16 and secured therein using a suitable matrix 22, such as non-conductive epoxy resin, or the like.

[020] It is also foreseeable that, instead of using the flexible printed circuit as described hereinabove, micro/nano fabrication techniques could be applied to a substrate patterned with a conductive material (such as those used for the fabrication of microchips).

[021] Referring to Figure 5, an illustrative application of the present invention in the mining industry will now be described. One important step in liberating minerals from ore bearing rock is milling the rock. Most ores contain the valuable metals disseminated in a matrix of less valuable rock called gangue. It is therefore necessary to separate valuable minerals from the gangue to yield a product that has a much higher content of the valued material. Following the initial mining step, ore is typically reduced in size by the crushing and/or grinding circuit, and the target mineral is concentrated by various methods. Ore milling typically refers to a specific subset of concentrating operations and is the focus of the present illustrative application.

[022] Milling operations typically utilise a mill (such as a SAG, AG, rod or ball mill), generally referred to using the reference numeral 100, which is comprised of a large drum 102 suspended at either end by a pair of supports 104, 106. Typical drum diameters range from about 2 metres to 12 metres. The drum 102 is capable of rotating around its axis 108 which is parallel to the ground. Rotation of the drum 102 is typically provided by a motor and, as necessary, a drive belt or the like (both not shown). The inside surfaces of the drum is lined with liners 110 and lifters 112. The lifters 112 have a raised profile and protrude towards the centre of the drum 102. Lifters 112 along the drums sides are arranged longitudinally in parallel with the axis of rotation 108. Lifters 112 along the charging end 116 or discharging end 118 are arranged radially to the axis of rotation 108. Course feedstock ore 120 is fed

into the drum 102 by an infeed assembly 122. Rotation of the drum 102 serves to lift the feed stock ore 120 which is then allowed to drop from a significant height. Three mechanisms cause the breakdown of the feedstock ore 120: impact due to the fall of the ore onto the charge below; attrition of smaller particles between larger grinding bodies; and abrasion or rubbing off of particles from the larger bodies. Additionally, steel or ceramic balls are sometimes added to the feedstock in order to aid the reduction process. Milled ore progresses towards along the drum and is discharged via the trunnion 124 or one of a number of peripheral discharges 126.

[023] Referring now to Figures 6a through 6d in addition to Figure 5, the lifters 112 can have a variety of different profiles depending on the ore being milled and milling process being used. Additionally, the lifters 112 can be manufactured from a variety of different materials such as rubber, cast iron, steel and other materials such as ceramics. As the milling process is largely abrasive, especially the lifters 112 are subject to a significant degree of wear. Additionally, this wear is typically uneven over the length of the mill drum 102. In some cases at the discharge end of the mill 118 wear of liners can be such that slurry racing occurs which leads to accelerated wear, compromise of the liner and possible wear of the shell itself. As such the lifters 112 must be frequently inspected and exchanged as necessary. This typically requires stopping and in some cases emptying the drum 102 which, as the milling process is a continuous process, can lead to significant inefficiencies in the use of the mill 100.

[024] Referring now to Figure 7a, in order to secure the lifters 112 to the inner surface 128 of the drum 102, typically a nut and bolt assembly comprised of, for example, a T-bolt 130 which is inserted into a corresponding slot 132 on the rearward surface 134 of the lifter 112 is used. Referring now to Figure 7b, by machining a small opening 136 through the slot 132 and into the

rearward surface 134 of the lifter 112 a opening for the insertion of the conductive element(s) as described hereinabove can be provided for. Once the opening is filled and suitable contact points provided for, the lifter 112 can be fastened to the inner surface 128 of the drum 102. It will now be apparent to a person of ordinary skill in the art that, with provision of signal relaying interconnections between the contact points and a suitable apparatus for measuring the status of these signal relaying paths, the wear of the lifters 112 beyond certain predetermined amounts can be determined without the necessity of halting the mill. Additionally, a series of small openings as in 136 could be machined or otherwise formed along the length of the rearward surface 134 of the lifter 112 and elements inserted and secured therein in order to provide sensing of wear over the length of the lifter 112.

[025] It is to be understood that the invention is not limited in its application to the details of construction and parts illustrated in the accompanying drawings and described hereinabove. The invention is capable of other embodiments and of being practised in various ways. It is also to be understood that the phraseology or terminology used herein is for the purpose of description and not limitation. Hence, although the present invention has been described hereinabove by way of preferred embodiments thereof, it can be modified, without departing from the spirit, scope and nature of the subject invention.

WHAT IS CLAIMED IS:

1. A sensor for sensing the erosion of a wear surface of a component, the sensor comprising:

an element comprising signal relaying paths between a first end and at least one second end, said element imbedded in the component such that only a portion of said signal relaying paths between said first end and each of said second ends comes within a predetermined distance from the wear surface; and

a circuit for sensing when said signal relaying path between said first end and each of said second ends has been damaged.

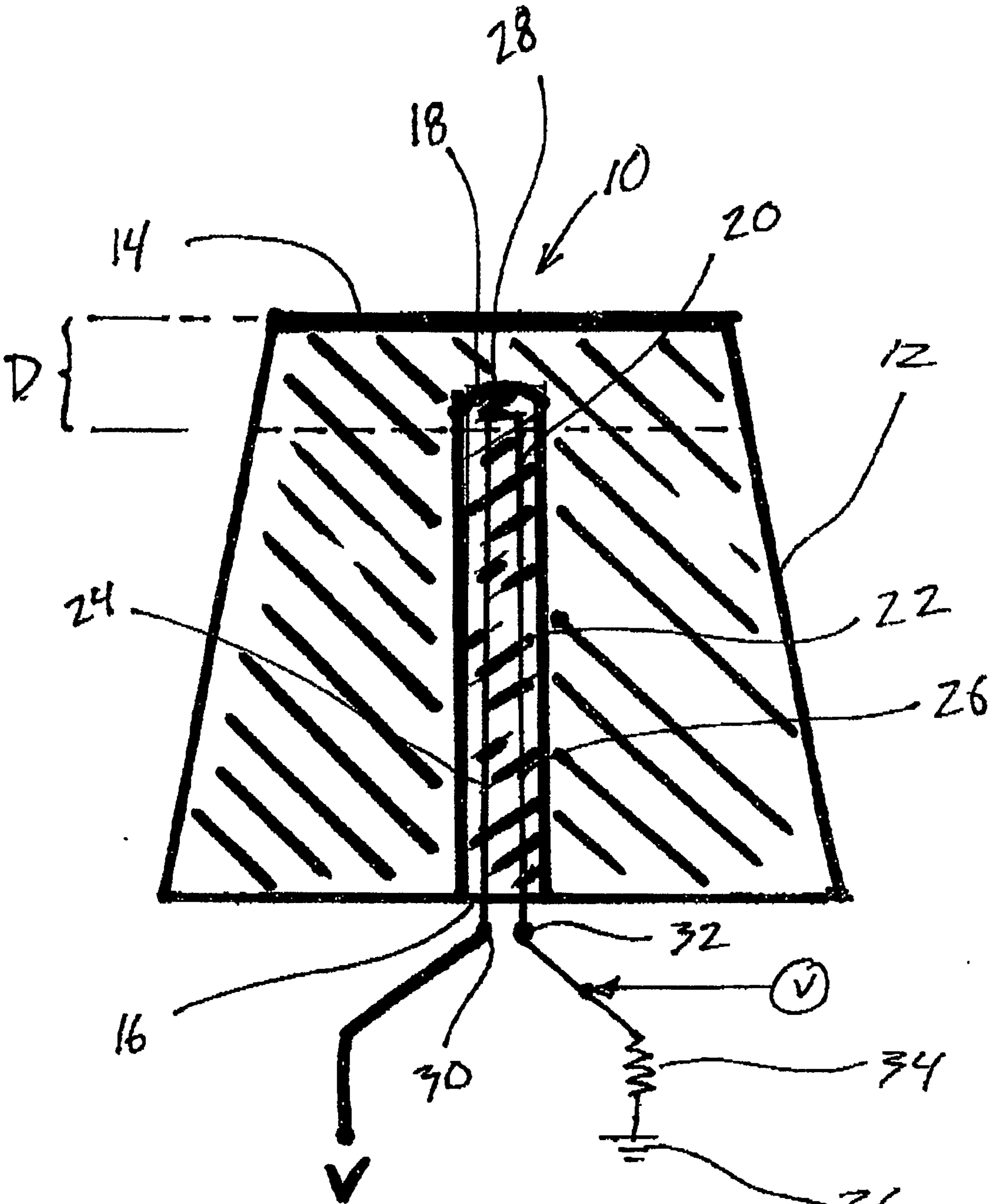


FIGURE 1a

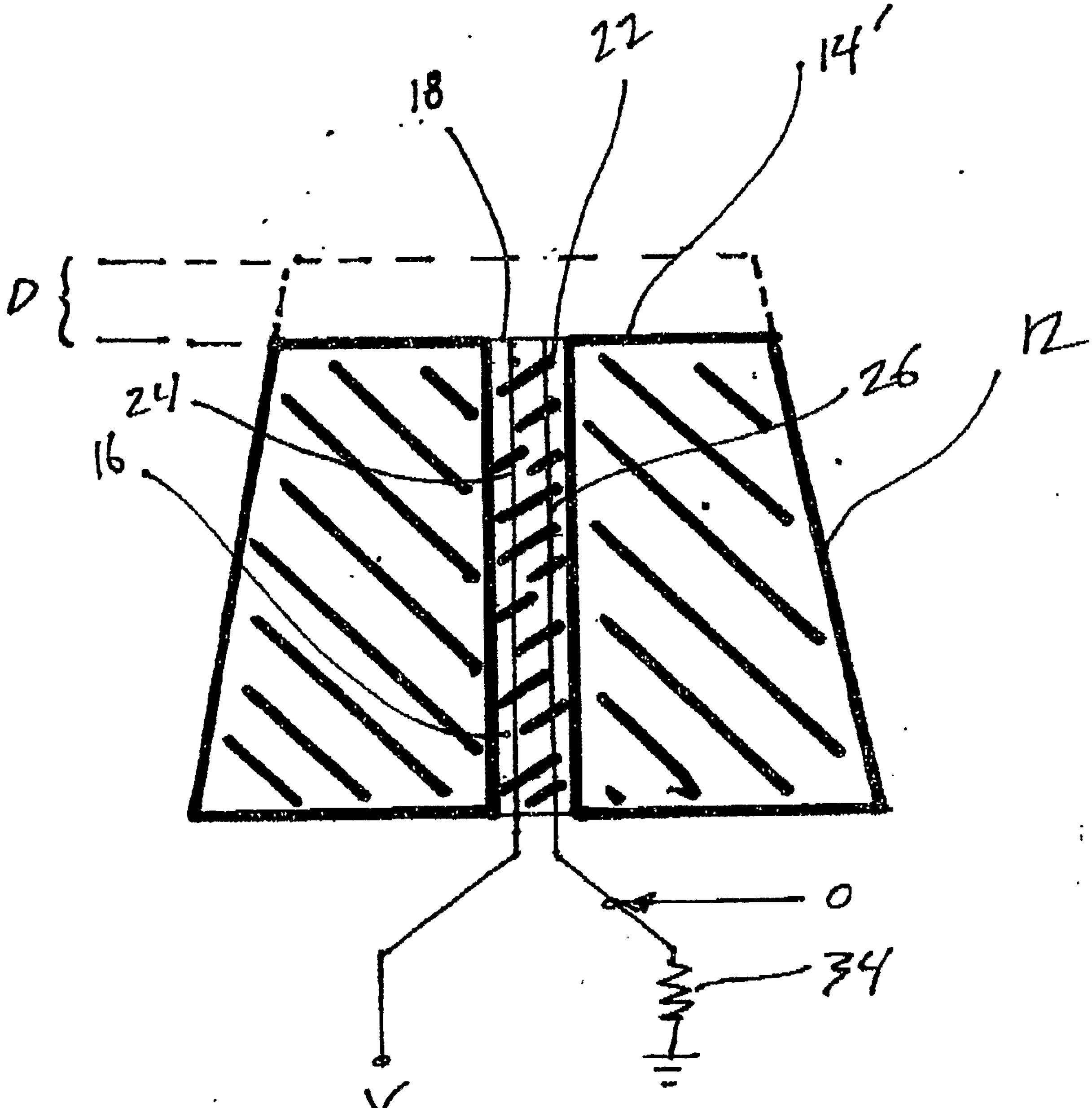


FIGURE 1b

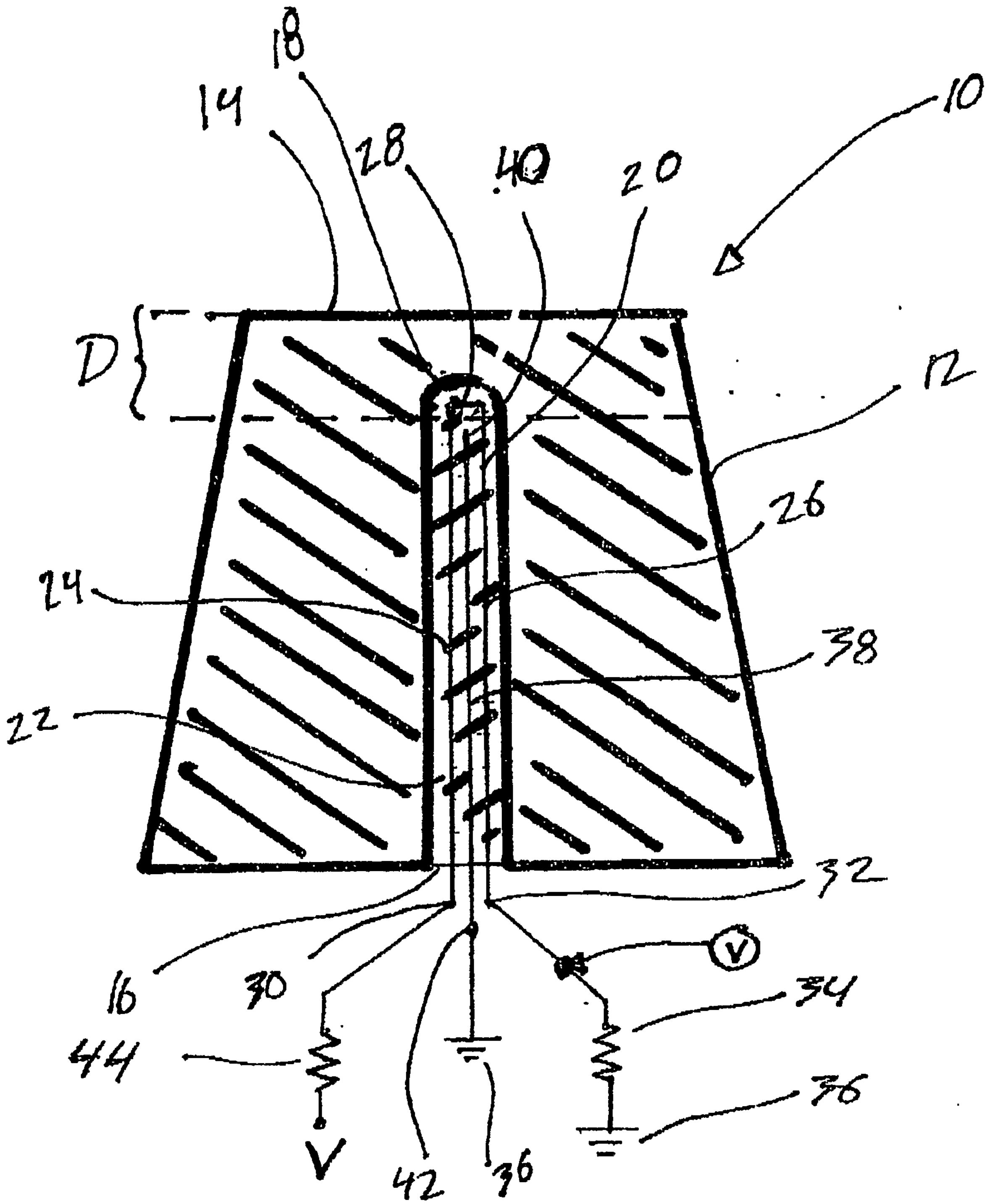


FIGURE 2

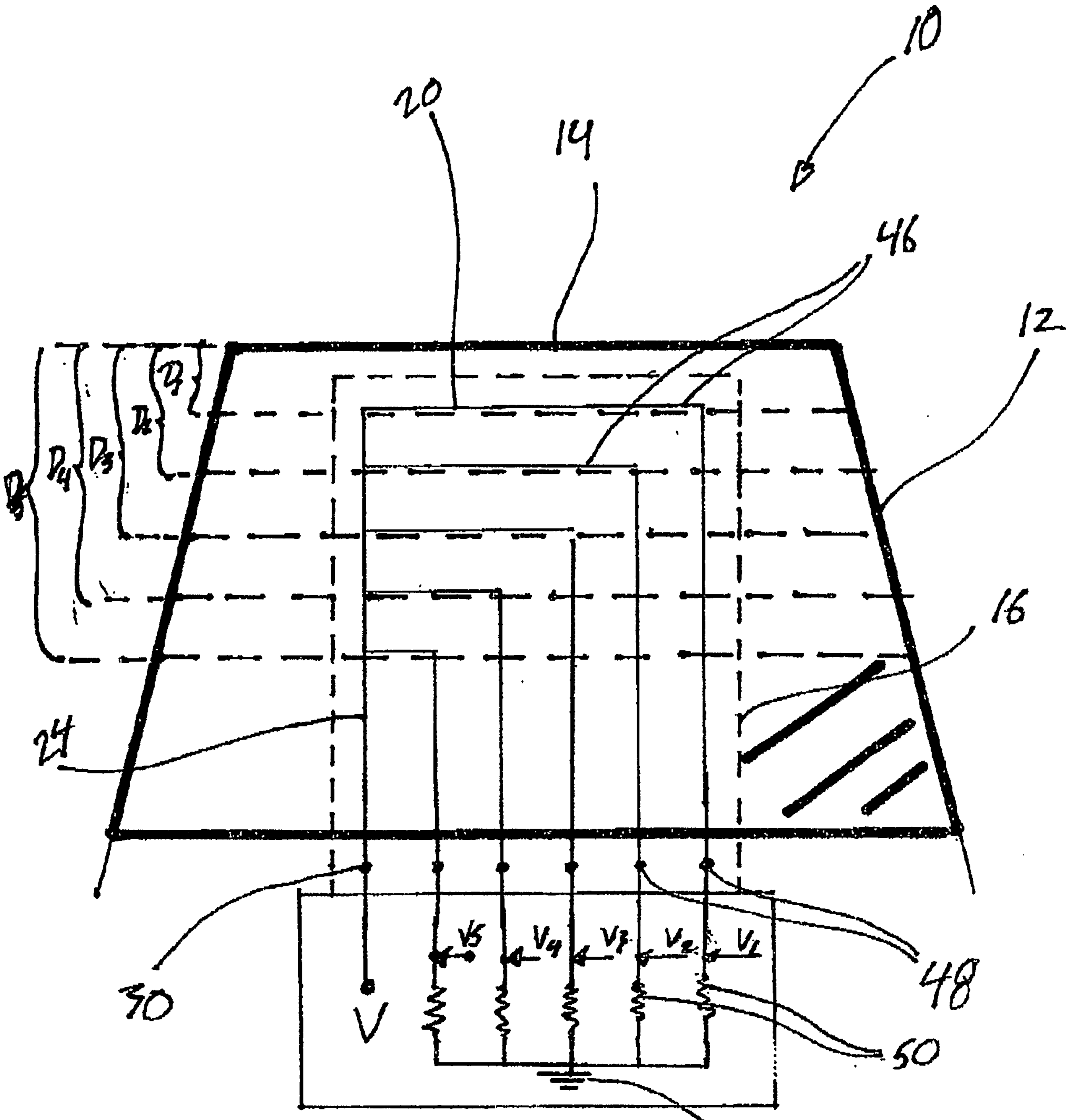


FIGURE 3

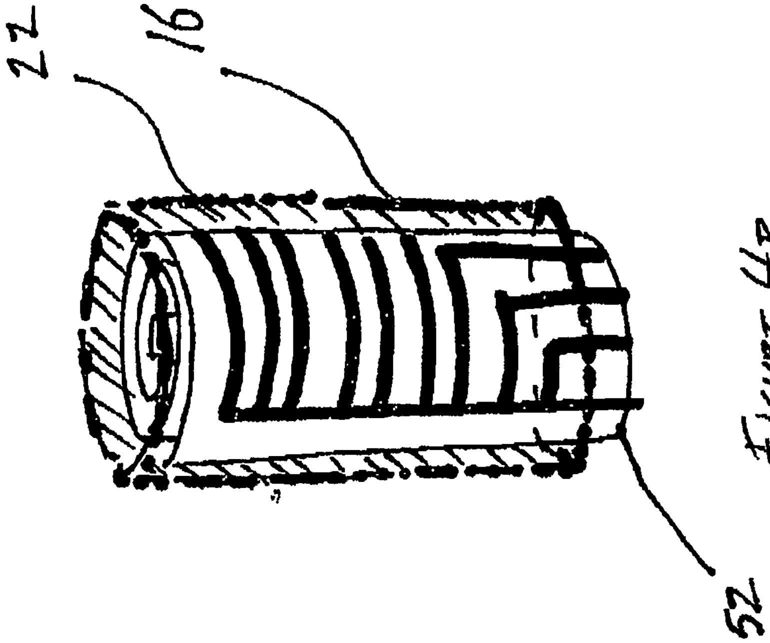


FIGURE 4B

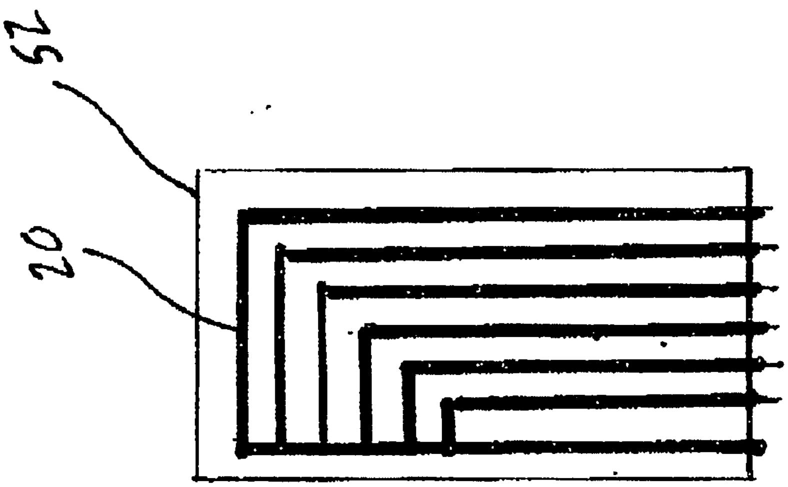


FIGURE 4A

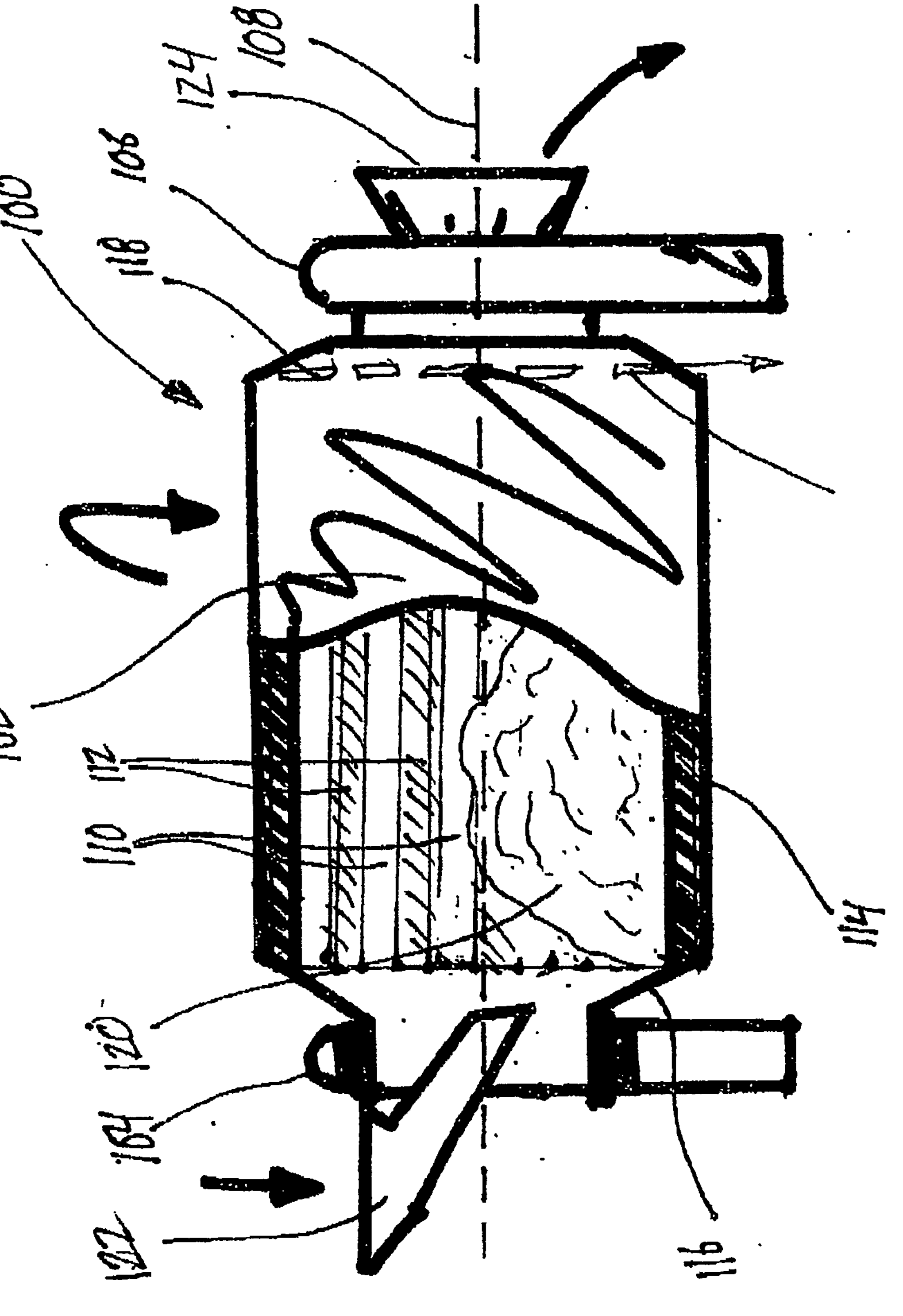


FIGURE 5

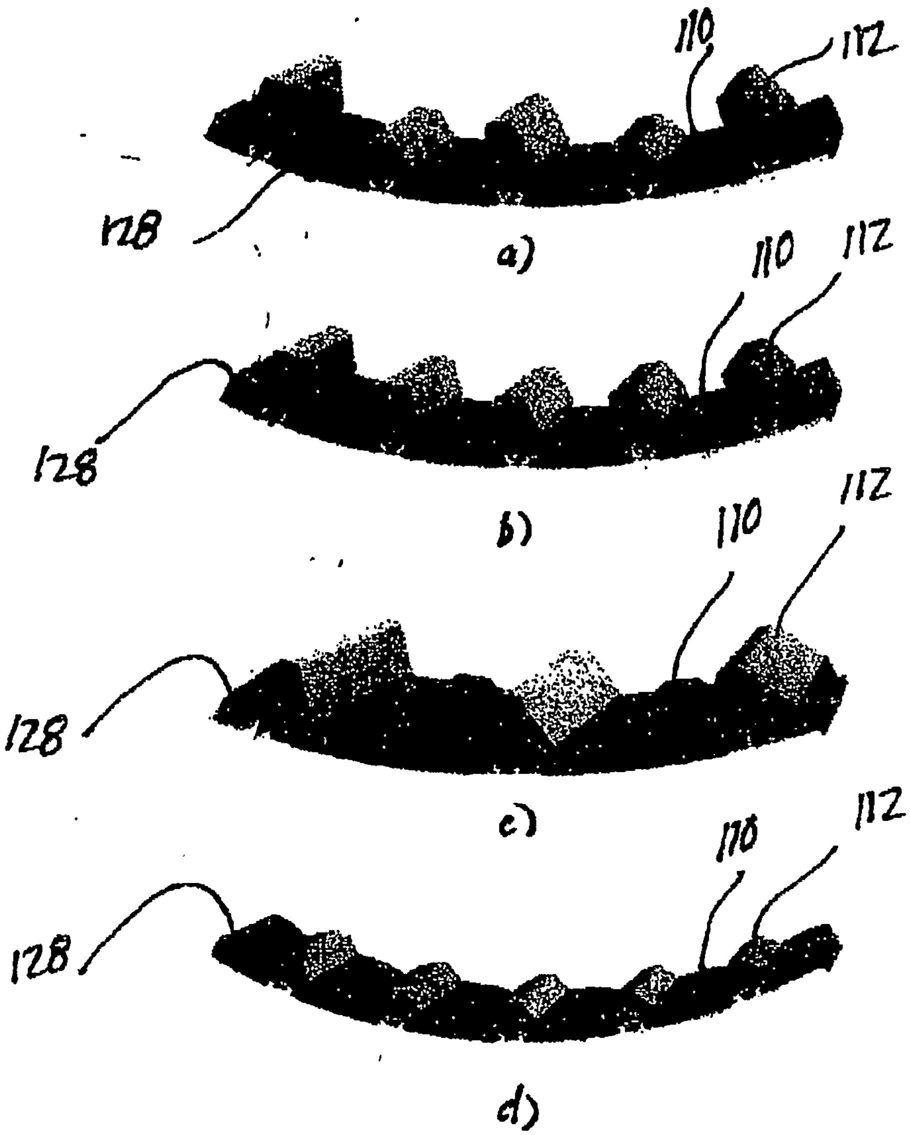
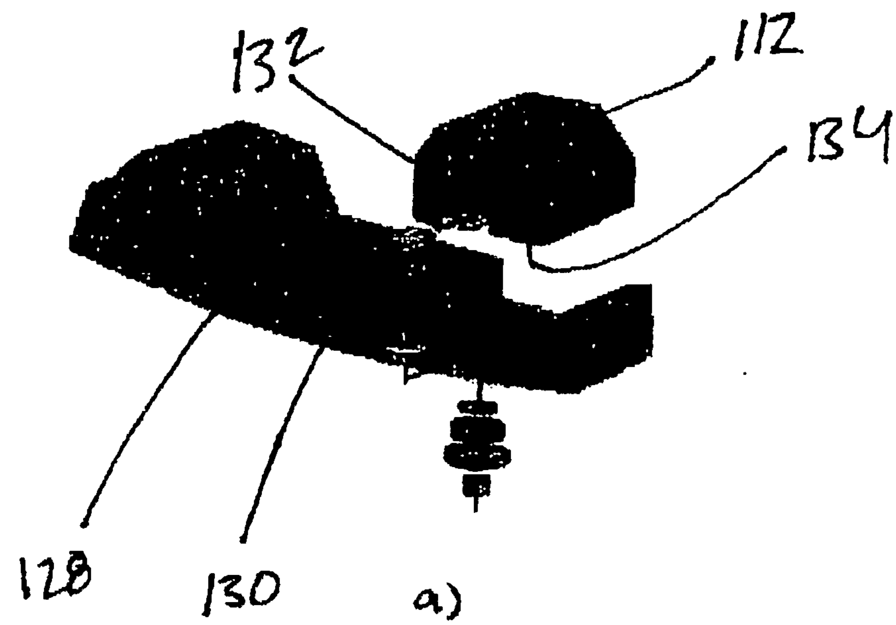


FIGURE 6



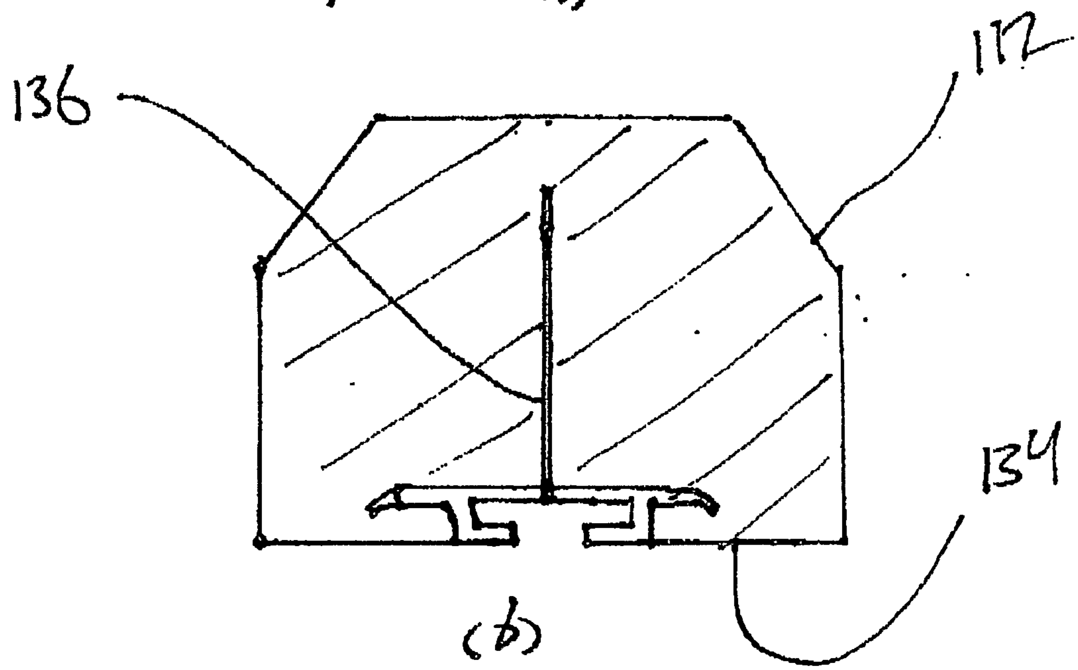


FIGURE 7